

**DEVELOPMENT OF A NEW HYBRID
REGRESSION MODEL: AN APPLICATION OF
FUZZY REGRESSION AND MULTILAYER
FEEDFORWARD NEURAL NETWORK
METHODS IN HERBAL MEDICINE RELATED
TO ORAL HEALTH KNOWLEDGE AND
PRACTICE**

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UNIVERSITI SAINS MALAYSIA

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by

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LIST OF ABBREVIATIONS

AIDS	Acquired Immuno-Deficiency Syndrome
CAM	Complementary and Alternative Medicine
CDK	Chronic Kidney Disease
DSAs	Dental Surgical Assistants
FR	Fuzzy Regression
GDP	Gross Domestic Product
HMOH	Herbal Medicine Related to Oral Health
KP	Knowledge and Practice
KS	Knowledge Score
MLE	Maximum Likelihood Estimator
MLFFNN	Multi-layer Feedforward Neural Network
MLR	Multiple Linear Regression
MSE	Mean Square Error
NN	Neural Network
PLRLS	Possibilistic linear regression with Least Square
PS	Practice Score
TFNs	Triangular Fuzzy Numbers
USM	Universiti Sains Malaysia

LIST OF APPENDICES

Appendix A	Ethical Approval
Appendix B	R software Syntax

**PEMBANGUNAN MODEL REGRESI HIBRID BAHARU:
APLIKASI REGRESI KABUR DAN KAEDAH RANGKAIAN SARAF
HADAPAN SUAPAN BERBILANG LAPISAN DALAM PERUBATAN
HERBA YANG BERKAITAN DENGAN PENGETAHUAN DAN AMALAN
KESIHATAN ORAL**

ABSTRAK

Ekstrak herba telah digunakan dalam kesihatan mulut untuk merawat pelbagai penyakit, termasuk keradangan, sebagai agen plak antimikrobial, antiseptik, antioksidan, pencegahan pelepasan histamin, dan sebagai analgesik antibakteria, antikulat, antivirus dan antimikrobial. Ubat herba juga berfungsi dalam penyembuhan, pengurangan plak dalam rongga mulut, dan peningkatan imun. Terdapat kajian minimum yang menggunakan regresi untuk menghubungkan pengetahuan dengan amalan dan pembolehubah sosiodemografi lain dalam HMOH. Untuk membangunkan model hibrid dengan mempertimbangkan bootstrap, rangkaian saraf dan regresi kabur untuk HMOH KP, untuk mengukur keberkesanan dan kecekapan model hibrid yang dibangunkan untuk HMOH KP, dan untuk mengesahkan model hibrid yang baru dibangunkan. Kajian ini bertujuan untuk membangunkan strategi terbaik untuk mengendalikan analisis data, terutamanya dalam HMOH KP, yang menggabungkan regresi kabur dan Rangkaian Neural Feedforward Berbilang Lapisan (MLFFNN). Perisian pengaturcaraan R digunakan untuk menulis sintaks yang telah dibangunkan. Semua langkah penting diringkaskan menerusi sintaks R. Model regresi hibrid baharu yang menggabungkan kaedah *bootstrapping*, MLFFNN, dan regresi kabur meningkatkan ketepatan parameter anggaran dan mengimbangi hubungan kabur di antara pembolehubah bersandar dan tidak bersandar. Kaedah MLFFNN telah berjaya

mengukur tahap keberkesanan, kecekapan dan ketepatan model hibrid yang baharu. Nilai R^2 dan nilai ramalan yang diperolehi digunakan untuk mengesahkan model terbitan. Tesis ini membentangkan metodologi baharu untuk mencipta model regresi yang tepat dan disahkan melalui penggunaan set data HMOH KP. Selain itu, pendekatan ini boleh diperluaskan kepada mana-mana set data lain yang sejajar dengan andaian yang disediakan.

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ABSTRACT

Herbal extracts have been utilized in oral health to treat various ailments, including inflammation, as antimicrobial plaque agents, antiseptics, antioxidants, histamine release prevention, and as antibacterial, antifungal, antiviral, and antimicrobial analgesics. Herbal medication also functions in healing, plaque reduction in the oral cavity, and immune enhancement. There is minimal research that has used regression to link knowledge with practice and other sociodemographic variables in HMOH. To develop a hybrid model by considering bootstrap, neural network, and fuzzy regression for HMOH KP, to measure the efficacy and efficiency of the developed hybrid model for HMOH KP, and to validate the newly developed hybrid model. This study aims to develop the best strategy for handling data analysis, especially in HMOH KP, which combines fuzzy regression and Multi-layer Feedforward Neural Network (MLFFNN). R-programming software is used to write the developed syntax. All the essential steps are summarized in the R syntax. The new hybrid regression model incorporating bootstrapping, MLFFNN, and fuzzy regression increases the precision of the estimated parameters and compensates for the ambiguous relationship between the dependent and independent variables. The MLFFNN method has successfully measured the effectiveness, efficiency, and accuracy of the new hybrid model. The R^2 value and the predicted value obtained are used to validate the

derived model. Conclusion: This thesis presents a new methodology for creating precise and validated regression models through the utilization of the HMOH KP dataset. Moreover, this approach can be extended to any other dataset that aligns with the provided assumptions.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

There are many justifications for advising patients to take herbal medicine, like the psychological comfort and a sense of control that come with taking action. Because they believe traditional medicine has failed to help them, most people with chronic, incurable diseases like cancer, arthritis, diabetes, or AIDS turn to herbal remedies. Herbal remedies are used by people with acute conditions like colds, bee stings, and sore throats because professional therapy is ineffective, difficult to obtain, costly, inconvenient, and time-consuming (Winslow *et al.*, 1998; Jose *et al.*, 2011).

Herbal remedies are healthier than synthetic ones. Moreover, herbal toxicity was associated with fewer adverse effects than conventional drugs, which were associated with higher harmful effects. Physicians frequently disregard herbs as harmless placebos (Winslow *et al.*, 1998; Kumar *et al.*, 2013).

The global use of herbal medicines continues to expand at a rapid rate. Many people use herbal remedies or other natural products to treat their health problems. In treating a wide range of conditions affecting the mouth, including inflammation, antimicrobial plaque agents, antiseptics, antioxidants, histamine release prevention, and antibacterial, antifungal, antiviral, and antimicrobial analgesics, herbal extracts have been used for centuries. Healing, reducing oral plaque, and boosting the immune system are additional functions of herbal medicine (Kumar *et al.*, 2013).

Most medicinal herbs are alkaline and antibacterial, which prevents mouth acidity, lowers plaque and calculus production, and lowers gum and periodontal diseases (Jose *et al.*, 2011). Some examples of medicinal plant sticks are Miswak and Neem (Kumar *et al.*, 2013; Tubaishat *et al.*, 2005).

Using regression for exploring the relations between knowledge and practice for different research areas, including Herbal medicine, is very common. Multiple linear regression (MLR) is one of the most common regression types that is used for this. On the other hand, bootstrapping, neural network, and fuzzy regression are still far away from this aspect of research since it is very rare to find a study about knowledge and practice, including those about herbal medicine, that used bootstrapped data in a neural network or fuzzy regression for testing the relations between variables.

The Bootstrap framework uses a random population sample to generate sample statistics. In order to construct a pseudo-population, the bootstrap duplicates the initial samples numerous times and then draws a number of substitutions. A sample the same size as the initial sample may be created using the bootstrap method, but this time, some findings are repeated more than once, and others are eliminated. The random sampling and substitution samples are distinct from those obtained solely by chance. The bootstrap method generates statistics for each sample as the replacement sample is drawn (Efron & Tibshirani, 1993).

Many problems can arise when the sample size is too small, distributional assumptions are broken, the relationship between independent and dependent variables is unclear, or events are ambiguous. The complexity of real-world problems makes the underlying models frequently insufficient, and information is often inaccurate. To overcome these limitations, many academics have updated and expanded statistical

regression analysis concepts using fuzzy set theory principles (Chukhrova and Johannssen, 2019).

The neural network is an iterative process that optimizes the target output by minimizing error (Gajendra *et al.*, 2018). In recent years, neural network (NN) models have been investigated to achieve human-like performance in several sectors of knowledge engineering. Applications employing neural networks are expanding fast as artificial intelligence tools in several fields. Numerous researchers have tried implementing neural networks for various purposes. The multi-layer perceptron (MLP) technique is one of the most commonly used artificial neural networks. (Selvakumar *et al.*, 2007).

In conclusion, knowledge and practice (KP) related to herbal medicine for oral health (HMOH) needs more statistical studies to explore the effect of sociodemographic factors on it and to predict and estimate knowledge or practice by having the newly developed model.

1.2 Research Motivation and Problem Statement

Determining the relationship between knowledge and practice is essential and requires much information and effort. The selection of the proper, valid, and reliable model is important because the model will then produce a good understanding of this relationship. This study aims to develop a new hybrid model using Bootstrap, MLR, and fuzzy regression (FR) to better and more accurately understand the relationship between knowledge and practice toward using HMOH. We know minimal research has used regression to link knowledge with practice and other sociodemographic variables in HMOH. The most common method used in the literature is the MLR alone. The limitation in the accuracy, especially in the variable selection of statistical

methodology in HMOH, motivates me to do this project. Therefore, this research attempts to fill this gap by suggesting a new hybrid model.

1.3 Research Questions

To fulfill the research objectives, therefore, the research questions are presented as follows:

- i. What is the contribution from the hybrid model that could improve HMOH KP performance and assist good decision-making?
- ii. What is the efficacy and efficiency of the developed hybrid model for HMOH KP?
- iii. How do the new hybrid model's results lead to this decision-making?

1.4 Research Objectives

Objectives of this study include:

General objective:

To elucidate the new hybrid model from bootstrap MLR and fuzzy regression for the knowledge and practice of herbal medicine for oral health.

Specific objectives:

- a. To develop a hybrid model by considering bootstrap, MLFFNN, and fuzzy regression for HMOH KP.
- b. To measure the efficacy and efficiency of the developed hybrid model for HMOH KP.
- c. To validate the developed hybrid model in (a).

1.5 Scope and Methodology

The statistical methods, especially (MLR) used for HMOH KP are insufficient to predict or anticipate the future value of any parameter. It needs a more accurate model for confirming choosing the independent variables and a wider range for prediction when the relations between variables are ambiguous. Because it can be used for estimation and prediction, fuzzy regression analysis is one of the most effective and powerful tools. This study focuses on a methodology building for a hybrid model, including bootstrapping, MLFFNN, and fuzzy regression, and applying this model to the HMOH KP dataset.

1.6 The Contribution of the Study

The study contribution includes KP toward HMOH. The second contribution is designing a new methodology encompassing all the stages required for bootstrapping, data modeling, and validation. Notably, the accuracy of the findings derived from this model should not be compromised. Accordingly, the suggested methodology ensures excellent predictability and accuracy in the generated model. This new methodology could be used with any other dataset if that data follows the inclusion and exclusion criteria for that research.

1.7 Limitations of the Study

This research aims to create an integrated methodology for KP related to HMOH that can be applied to regression analysis. Therefore, two case studies selected from a prior study will test the created approach utilizing retrospective study data. Moreover, the process employs only particular statistical tools (e.g., bootstrap, MLFFNN, and fuzzy regression). Only datasets with single dependent and k-independent variables (factors) will be examined to test the methodology.

1.8 Organization of the Thesis

This thesis is divided into six sections. Chapter One gives an introduction and overview of herbal medicine related to oral health and the various statistical methods covered in this research, including bootstrap, MLR, MLFFNN, and fuzzy regressions.

Chapter Two focuses on how the literature covered these topics. It includes covering the history of using herbal medicine and its importance for oral health, knowledge about herbal medicine, practice toward herbal medicine, Illness types, and herbal medicine, the accessibility of herbal medicines, advantages and drawbacks of using herbs for oral health, and the most popular herbs used for oral health. Then, this chapter will cover the practice toward bootstrap, MLFFNN, and fuzzy regression and their applications in biostatistics. Furthermore, it will discuss using a regression for KP research.

Chapter Three introduces the methodology this study followed and contains detailed information on the data selection procedure and the formulation of statistical programming used to test the method. The results obtained from this study are covered in Chapter Four. The findings are discussed with regard to each objective in Chapter Five. The last chapter in this study is Chapter Six, which discusses the conclusions from this study and the recommendations.

1.9 Conceptual framework

This framework in Figure 1.1 is the anchor for our research, elucidating the core theories and connections that will guide our study. The more extensive scope is Medicine for oral health. Phase I focuses on the herbal section of traditional medicine. KP and sociodemographic variables will included as the variables. In Phase II, the methodology building, KP was used as two case studies after cleaning from outliers.

Then, Bosstrapping and MLFF were applied to manage the efficacy and efficiency of the model. The next step was applying the FR model. R2 and predicting value were calculated for model validation.

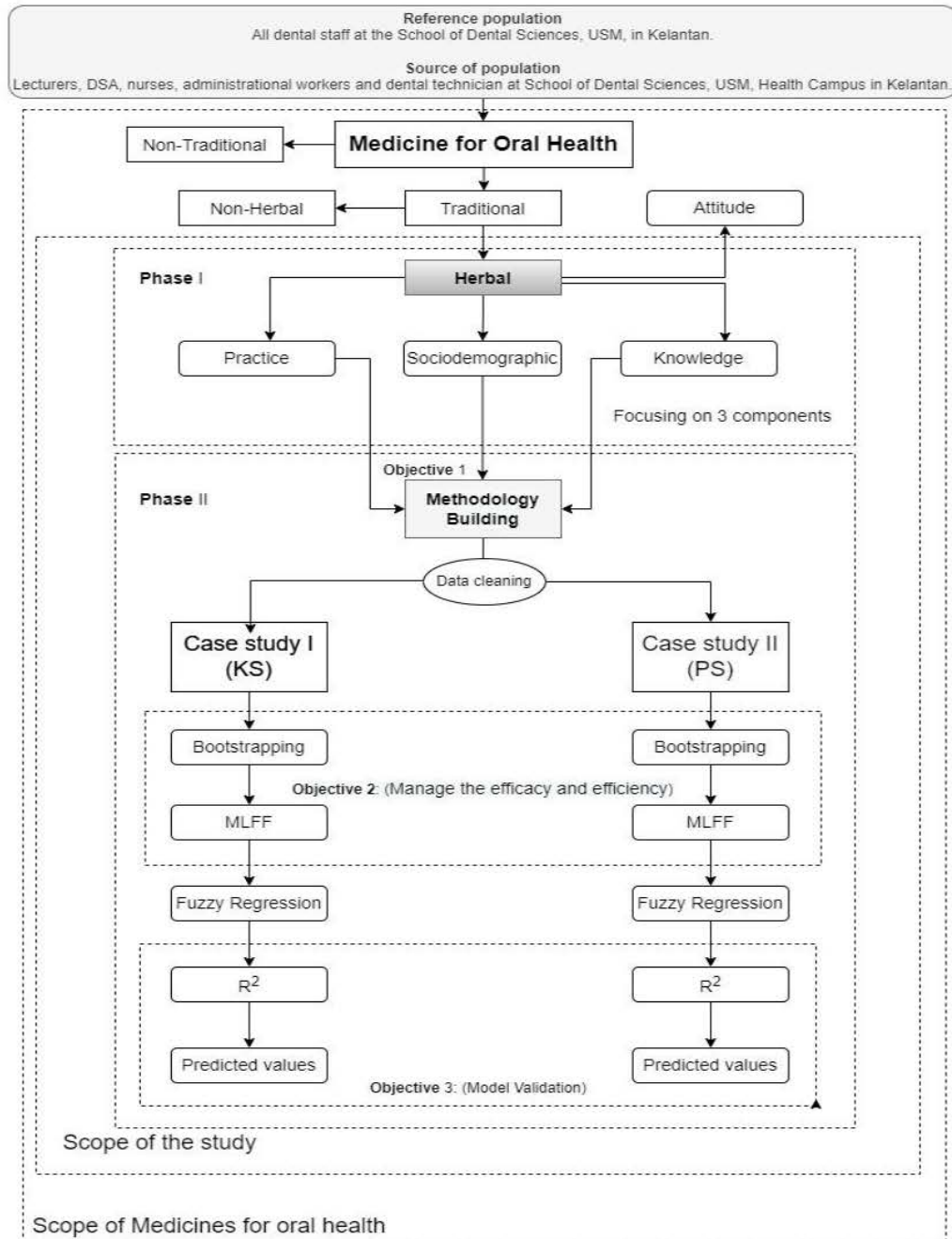


Figure 1.1: Conceptual framework and flow chart of the study

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of the Chapter

In Section 2.2, the use of herbal medicine is discussed. A brief history and explanation of MLFF neural networking, fuzzy regression, and linear regression are also provided in Section 2.3. In Section 2.4, the application of statistical methods discussed in various scientific papers is further examined. These statistical techniques (linear regression, fuzzy regression, and MLFFNN) are generally discussed in Section 2.5, along with any potential drawbacks. Additionally, Section 2.6 emphasizes the need for a combination strategy due to the limitations of statistical approaches. Final thoughts are included in the last section.

2.2 Using Herbal Medicine for Oral Health

Humans had used herbal therapies before writing history (Jain *et al.*, 2015). Plant sources are used to make a variety of pharmaceuticals. The majority of effective medicines in the 20th century were made from herbs. Quinine is made from cinchona bark, aspirin is made from willow bark, morphine is made from opium poppies, and digoxin is made from foxglove (Jain *et al.*, 2015).

Nearly 50,000 deaths per day are attributed to infectious diseases, considered the world's leading cause of premature mortality (Ahmad and Beg, 2001). Drug resistance against human pathogenic microorganisms has recently been well-documented globally. This issue affects the world because antibiotics are used globally, including in industrialized, emerging, and underdeveloped nations (Ahmad and Beg,

2001). The two diseases associated with treating infectious diseases in immunocompromised people most frequently drug-resistant are AIDS and cancer (Berendonk *et al.*, 2015). Most antibiotics used to treat oral and dental infections, such as penicillins, erythromycin, tetracycline, and its derivatives, cephalosporins, and metronidazole, are ineffective against oral diseases (Palombo, 2011).

Antibacterial medications like chlorhexidine and amine fluorides are harmful and occasionally stain teeth when used to prevent and treat oral disorders. Additionally, mouthwashes with alcohol increase the risk of oral cancer (Palombo, 2011). This has forced a search for an alternative, secure antibacterial agent. One of the best options for treating this problem is using herbs (Ahmad and Beg, 2001)

Traditionally, many chemical compounds with therapeutic properties are produced by medicinal plants (Ahmad and Beg, 2001). When developing novel antimicrobial medications, the new substance must have the ability to either eradicate or retard the spread of infections while posing little to no toxicity to host cells (Ahmad and Beg, 2001). A recent study has shown these characteristics of medicinal plants (Ahmad and Beg, 2001). Additionally, some plant and herbal extracts showed pathogen target sites that were different from those of antibiotics. *Some examples include the inermis, various Eucalyptus species, C. equistifolia, H. indices, and H. antidysenterica.* These plants may help treat medication-resistant infections (Ahmad and Beg, 2001).

Finding new suppliers of antibacterial drugs is essential. This is true because of the aforementioned elements, the adverse effects of some antibiotics used in dentistry, the prevalence of oral diseases, and the financial constraints in developing countries (Jain *et al.*, 2015). Herbal preparations are considered effective alternatives to synthetic chemicals (Palombo, 2011; Ahmad and Beg, 2001).

An epidemiological study found that complementary and alternative medicine (CAM) is used by between 70 and 80 % of people worldwide. Due to the fact that, when used at a sufficient concentration, herbal medications do not interfere with or change the normal flora in the mouth cavity, herbal dentistry is becoming more popular. For instance, herbal toothpaste with herbal derivatives is antibacterial and reduces plaque development properties. Herbs are also widely used to maintain oral hygiene, with eucalyptus leaves used to cover bad breath and onion and lime juice used as gargles and pain relievers for toothaches (Seal *et al.*, 2016).

Herbal medicine works because herbal extracts interact with specific chemical receptors in the body in a pharmacodynamic sense. The effects of herbs on oral tissues, their mode of action, and any potential adverse effects are all considered. Consequently, a thorough understanding of using herbs for oral health is necessary (Seal *et al.*, 2016).

The human oral cavity is home to more than 750 different species of bacteria, nearly half of which are still unknown. Many bacteria contribute to oral diseases. *Streptococcus mutants*, *S. sobrinus*, *Lactobacilli*, and *actinomycetes* are acidogenic and aciduric Gram- +ive bacteria that play a part in developing dental caries by converting sucrose into lactic acid or other organic acids (Palombo, 2011). Demineralization of teeth and calcium phosphate dissolution in teeth, which results in decalcification, are caused by organic acids. The ability of *L. inermis*, *Eucalyptus sp.*, *H. indicus*, *C. equistifolia*, and *H. antidysenterica* to combat cariogenic bacteria was discovered (Ahmad and Beg, 2001).

Gram-negative anaerobic oral bacteria like *Porphyromonas gingivalis*, *Prevotella*, *Actinobacillus*, and *Fusobacterium* have been linked to subgingival periodontal diseases. In periodontal diseases, the diseased areas are at or below the gingival

pocket cause an inflammatory reaction in the connective tissue surrounding it and the gingival tissue (Palombo, 2011). It can cause periodontitis or gingivitis (bleeding, swelling, and redness of the gum tissue) (loss of collagen attachment of the tooth to the bone and loss of bone). As Palombo (2011) noted, herbs are among the best choices when looking for substances that can control these microorganisms with the fewest side effects.

2.2.1 Knowledge About Herbal Medicines in Medical and Oral Health

Herbal medicine is used to treat various oral problems. Therefore, it is essential to have a thorough understanding of it. Knowledge of medicinal plants includes dose information, which is essential for determining if the amount used is hazardous. Additionally, awareness of safety is essential. All medicinal herbs and plants should be evaluated to see whether or not they are safe for therapy. The second sort of knowledge is the length of therapy by herb owing to the likelihood of toxicity if some herbs are taken for an extended time (Ranjarisoa *et al.*, 2016).

Patients must be informed of herbal drugs' responses, advantages, and potential side effects while using them to treat various oral cavity diseases. In addition, oral health care practitioners should compile information about herbs and plants used orally and their qualities since they are a reliable source of medical knowledge (Kim and Lean, 2013).

Even though many herbs are safe to use and devoid of side effects, some have been proven to have adverse effects. Some herbs' adverse effects on the oral cavity included pulp necrosis, which led to toothache relief. In addition, some herbs might cause burns, commonly connected with oral ulcers and chronic halitosis (Ashu and Naidoo, 2015). Traditional treatments for halitosis include deodorization with garlic

extract, milk consumption, mushroom extract, tea catechins, plant extracts containing polyphenol and phenolic derivatives, and honey. Therefore, it is essential to understand herbs for treating oral diseases, particularly when employing unusual plants (Ashu and Naidoo, 2015).

Kim and Lean (2013) performed research at Hospital Universiti Sains Malaysia in Kelantan, Malaysia, to assess the degree of awareness and use of herbal medications among 460 pregnant women. It revealed that the mean (sd) knowledge score was 14.34 (3.37). Most women (89.8 %) had little herb knowledge, whereas 10.2 % had strong herb knowledge. Only 8.5% of women report being aware of the contents of herbal remedies. However, none could identify the components of the herbal drugs they drank. In all, just 11.5% of female participants knew that herbal medicines might be contaminated with microorganisms, mercury, or other contaminants.

In another study, Farooqui et al. in 2016 examined the usage of complementary and alternative medicine (CAM) among Malaysian cancer patients. It suggests that patients are unaware of the negative interactions between CAM and conventional medicines. The study found that friends and family were the most valuable information sources for medicinal herbs (Farooqui *et al.*, 2016).

In 2015, Stanifer *et al.* conducted a study in northern Tanzania to look at how patients with chronic renal disease used traditional medicine. The findings indicate a connection between chronic renal disease sufferers' low knowledge levels and high reliance on conventional medicine (Stanifer *et al.*, 2015).

Medicinal herbs and plants will be passed down orally from one generation to the next. However, most younger generations lack knowledge of recognizing, gathering, preserving, and using various medicinal plant species (Jose *et al.*, 2011). This

demonstrates the need for more studies into the safety of herbal remedies, inadequate doses, and dosing formats (Kim and Lean, 2013). Previous research suggests that the inadequacy of dose and dosage forms may be influenced by various cultural ideas, practices, geopolitical regions, and perspectives on beliefs and effects of their intake (Kim and Lean, 2013).

Usually, people learn about herbal medicine from their friends and family rather than from a doctor. This was corroborated by research looking at the use of conventional therapies among cancer patients in Malaysia (Farooqui *et al.*, 2016) and among community members with chronic kidney disease (CKD) in northern Tanzania. Therefore, more trust can be placed in friends, family, elders, traditional healers, and herbalists (Stanifer *et al.*, 2015).

Maji Jose *et al.* (2011) researched medicinal plants used for oral health in Kannada, India, and found that only a few community elders still follow traditional practices. This was because young people lacked interest and had limited access to herbs. Modern conveniences also impact people, which endangers the knowledge of medicinal herbs. However, using high-potency medicinal plants will provide simple and affordable healthcare alternatives to combat the rising prevalence of oral disorders (Jose *et al.*, 2011).

2.2.2 Practice Toward Herbal Medicines for Medical and Oral Health

Herbal preparations are used to treat a vast diversity of medical ailments worldwide. Examples include fever, infectious disorders, debility, autoimmune diseases, and malignant diseases. In addition, it is utilized to treat system dysfunctions (digestion and intestine, liver, biliary system, cardiovascular system, urinary system,

respiratory system, female reproductive system, neurological system, joint disorders, and skin illnesses (Mills, 2000).

Due to the country's ethnic diversity and belief in traditional healing using natural resources, herbal cures were widely used in Malaysia (Siti *et al.*, 2009). According to research on the herbs and plants used by traditional healers to treat oral health issues, 52 plants were used by the Cameroonian population. Antibiotics are frequently used to treat conditions like toothaches, mouth sores, sore throats, mouth ulcers, abscesses, bullous lesions, dentine sensitivity, fractured teeth, mouth thrush, tooth decay, gingivitis, tonsillitis, sinus infections, oral syphilis, dry mouth, and oral cancer. The plant parts most commonly used to treat oral health issues are roots, leaves, and bark (Ashu and Naidoo, 2015).

Administration processes differ from country to country depending on the administered component and the ailment being treated. For example, eating leaves treats aphthous, spongy gums, and tooth decay (Ranjarisoa *et al.*, 2016). According to a study on using plants in oral health conducted by Ranjarisoa *et al.* (2016) in Mahajanga, Madagascar, the most prevalent mode of administration is a direct application to the cavities or gum for an immediate effect. Antibacterial herbs can be effective if applied directly to bacterial plaque.

The same study claims that Madagascar used the *Solanum incanum* L. (*S. incanum*) plant in a novel way to treat dental caries. To get the necessary teeth, slice a few *S. incanum* fruits in half, rub the seeds on some corn cobs, and then burn the seeds with some *Jatropha curcas* L. almonds or beef fat. The fruits and seeds had to be smoked like cigarettes to be used as a toothache remedy occasionally (Ranjarisoa *et al.*, 2016).

In some locations, toothache sufferers create herbal fillings or chew the bark of particular plants to alleviate pain (Martinez *et al.*, 2017).

Kim and Lean (2013) studied pregnant Malay women's use of herbal remedies. They discovered that the use of natural medications was highly prevalent. The primary justification was the misconception that these plants are innocuous and have no detrimental effects (Kim and Lean, 2013).

The study by Stanifer *et al.* (2015) in northern Tanzania on using herbal medications by people with renal disease indicated that tea, soup, inhalation, chewing, milk, and bathing were the most common delivery methods (Stanifer *et al.*, 2015). These procedures do not apply to oral health since topical treatments are the norm.

2.2.3 Advantages and drawbacks of using herbs for oral health

Dental care and treatment costs make it difficult for people to access the necessary services and medications, especially in developing and underdeveloped nations (Maupome *et al.*, 2013). Herbal medicine, on the other hand, is widely accessible and reasonably priced, making it simple for anyone to obtain as a viable option. Herbal treatment offers several potential benefits in dentistry. Due to several active compounds with preventative benefits, regulatory action, stimulation of the body's defensive mechanisms, and antimicrobial properties, certain herbs are more successful than pharmaceuticals in treating oral disorders (Martinez *et al.*, 2017).

Due to their qualities and potential for avoiding oral disorders such as gingivitis and dental caries, several herbal extracts have lately become the subject of inquiry (Moreno *et al.* 2006). Herbal screening must come first in drug development because it is frequently the primary source of novel medications (Lautie *et al.* 2008). One example is eugenol, an essential component of several dental treatments (Da Silva *et al.* 2012).

Herbal medicine is cost-effective, widely accepted by the public, treats illnesses cheaply, and makes accessing periodontal disease prevention and treatment easier. Consequently, herbal treatments are important therapeutic resources for restoring health, including treating oral diseases (Batista *et al.*, 2014).

Using zinc oxide and eugenol with *Uncaria tomentosa* paste for direct pulp capping was evaluated by Lahoud *et al.* in (2000). The outcomes showed that the Paste from *U. tomentosa* was more efficient in treating pulp inflammation, promoting better dental reformation, and combating various oral pathogens.

The avocado is a well-known medicinal plant (*Persea americana*). By preventing the growth of harmful microorganisms, an avocado can be used to treat periodontal disease, according to a 2012 study by Rosas-Pinon *et al.* Furthermore, periodontal ligaments showed inhibition of interleukin 1b (Andriamanalijaona *et al.* 2006). Avocados could potentially help to prevent diseases of the mouth.

However, several drawbacks are associated with using and applying herbal medicines. In many developing nations, the storage of medicinal plant products is a significant issue for herbal and traditional medicine. The technologies for postharvest processing and storage need to be improved. It is essential to tackle this challenge to enable the creation of high-quality, safe, and effective treatments (Ashu and Naidoo, 2015).

Inaccurate diagnosis, inappropriate doses, the secrecy of some treatment procedures, low hygiene standards, and the lack of patient records are the other major downsides of herbal medicine use (Ashu and Naidoo, 2015). Patients who use herbal remedies have no instruments for diagnosing oral discomfort or evaluating treatment

outcomes. According to Ashu and Naidoo (2015), most patients rely only on their symptoms.

2.2.4 Illness Types and Herbal Medicines

Oral health treatment might be influenced by the nature and classification of a patient's ailment. For example, plaque control consists of brushing, which is the most popular way of mechanical biofilm removal, even though it is sometimes difficult and does not permit adequate control. It needs patience, persistence, and manual dexterity (Jain *et al.*, 2015). Therefore, many patients receive scaling and root planning despite using a toothbrush. However, periodontal pathogens in untreated sites and pathogens found in the tongue, saliva, oral mucosa, and tonsils have a chance of reinfecting treated sites. Based on this, a new protocol for complete mouth chemical control, including mouthwashes, was advised (Batista *et al.*, 2014).

Chemical management of dental biofilm provides an additional tool due to the limitations of mechanical dental care techniques. Additionally, using antimicrobial substances in mouthwash helped prevent and treat dental and gingival issues by reducing the number of harmful bacteria in the mouth. Inhibiting the growth of microorganisms, preventing the development of the intercellular biofilm matrix, altering the bacterial biochemistry to lessen toxicity, and altering the ecology of the biofilm to produce a less pathogenic microbiota were some functions of the antimicrobial mouthwash agent (Teles *et al.*, 2009).

The most effective chemical treatment and preventative measure for gingivitis is chlorhexidine, an effective antimicrobial agent. It may discolour the tongue, teeth, and dental restorations when used for an extended time. It may also cause oral scaling, sensitivity, allergic reactions, a bad taste, and gustatory disturbances (Teles *et al.*, 2009).

Consequently, it is necessary to design a material with significant antibacterial activity capable of interfering with the production of biofilms while minimizing negative effects.

For dealing with these issues, herbal antimicrobials are preferable to chemical antimicrobials. Sanguinaria is an astringent, diuretic, and anti-inflammatory plant sometimes used as a mouthwash (*Polygonum aviculare* L.). This herb was extensively used in Mexico to cure gingivitis by reducing inflammation (Martinez *et al.*, 2017). Additional studies looked into the effects of an aloe (aloe vera) mouthwash, including its bacterial and anti-inflammatory qualities. Aloin and emodin, two active substances found in aloe vera, may cause these effects (Surjushe *et al.*, 2008). The outcomes showed that *S. aureus* growth was inhibited by aloe vera gel and leaves. The leaf inhibited the growth of both *Candida albicans* and *Pseudomonas aeruginosa*, and the gel blocked the growth of *Trichophyton mentagrophytes* (Agarry *et al.*, 2005), suggesting its effectiveness in treating gingival inflammation and lowering plaque (Vangipuram *et al.*, 2016).

Additional research on Indian herbs used to colonize the cariogenic *Streptococcus mutans* was done by Jain *et al.* (2015). These plants have been used traditionally to treat various ailments, including infectious diseases. Additionally, these plants' phytochemicals work well against bacteria resistant to many drugs (Jain *et al.*, 2015).

Recently, many plant extracts, including neem leaf, burdock root, and noni fruit, have been used as root canal treatments with spectacular results in periodontics and endodontics, paving the door for herbal medicine to play a significant role in dentistry

(Shah *et al.*, 2015). The chicalote root was a trustworthy anaesthetic used to treat toothaches in Mexico (Martinez *et al.*, 2017).

The majority of people utilize medicinal herbs to manage symptomatic conditions. This is one finding of the study conducted by Stanifer *et al.* in northern Tanzania (2015). The study also revealed that herbal medications were utilized less frequently for cancer treatment and disease prevention. However, the practice may differ orally.

2.2.5 Socioeconomic and Herbal Medications

Herbal therapy had the highest rate of all categories compared to other traditional therapies, according to a baseline study by Stanifer *et al.* (2015) on the use of traditional and complementary medicine in Malaysia. Except for those over 80, it was used by over 80% of all age groups. The study also discovered that women are slightly more likely to use herbal remedies than men. The percentage of Orang Asli who use herbal remedies is roughly 93%, regardless of ethnicity, employment status, or educational level (Siti *et al.*, 2009).

The use of CAM by cancer patients in Malaysia was studied by Farooque *et al.* (2016). According to reports, there was no conclusive link between ethnicity and CAM use. The majority of Malay women reported using CAM therapies for cancer.

In their 2013 study on herbal remedies by Malaysian pregnant women, Kim and Lean found a significant relationship between age and herbal use. In this study, the occupation groups were jobless and employed, although there was no significant correlation between occupation and herb use. Also, no significant correlation with educational attainment was discovered. However, the study revealed a correlation between herbal consumption and income. A 2005 study by Tubaishat *et al.* on using

Miswak for dental health in Jordan found no correlation between herbs and age or gender.

2.2.6 The Accessibility of Herbal Medicines

Based on the nation, the literature identified that herbal remedies used for primary dental care may have different indications, administration methods, and plant components. However, some researchers have shown that herbal treatments are limited to rural areas and are less common in urban settings. Herb availability in rural locations is higher than in urban areas, which may result from cultural attitudes (Seal *et al.*, 2016). However, according to Stanifer *et al.* (2015), there is no association between place (rural/urban) and usage of herbal medicines, and the difference between the two is not statistically significant (Stanifer *et al.*, 2015).

2.2.7 Popular Herbs used in oral health

Numerous oral problems have been treated with hundreds, if not thousands, of herbs with therapeutic effects on oral health. The following plants are frequently utilized in dentistry:

Salvadora persica, known as Miswak, has been used for millennia in various goods, including chewing gum, toothpaste, and powder (Tubaishat *et al.*, 2005). The high sulfate content of *S. persica* extract may be responsible for its inhibitory effects on *Candida albicans*' growth. Except for *S. mutans*, miswak extracts exhibit antibacterial activity against *S. mutans* and *E. faecalis* and have significantly fewer cariogenic bacteria than toothbrush users (Halawany, 2012). It significantly affects periodontal health, gingival health, and tooth plaque. In areas where Miswak is often used, there are low rates of adult tooth loss (Almas, 2001).

The *Azadirachta indica*, also called Neem, is used to create toothpaste, mouthwash, and chewing gum. This herb has been used medicinally in India and other parts of Asia for thousands of years. Plaque, bleeding, and gingival and periodontal diseases dramatically decreased by its extracts. Preparations from the tree are reportedly effective for treating various inflammatory and infectious diseases (Botelho *et al.*, 2008).

Carica papaya: More than 20 diseases have been treated with its seed and pulp (Ashu and Naidoo, 2015). *Staphylococcus* and other typical oral and dental germs are resistant to it because it is bacteriostatic. It has been demonstrated that the latex of *C. papaya* inhibits *C. albicans* development by 60% and that its fruits when applied topically to ulcers, encourage granulation and healing. Because of this, it can be used to treat mouth sores like aphthous ulcers (Ashu and Naidoo, 2015).

Despite being associated with oral cancer, *Nicotinia* tobacco, also known as tobacco and known in Malay as Daun Tembakau, is still used to cure toothaches by coating the affected tooth with a mixture of calcium carbonate and tobacco leaves. Teeth can also be whitened using it. Smokeless tobacco boosts endorphin circulation, which can alter how the central nervous system perceives pain (Ashu and Naidoo, 2015).

Malay for “aloe vera” (Lidah buaya). Aloe vera roots were directly put into tooth cavities to relieve discomfort. Aloe vera’s capacity to reduce bacterial cell protein synthesis is thought to be the basis for its antibacterial activities. It also acts as a humectant and has anti-inflammatory and wound-healing qualities. This plant eliminates the bacterium *Pseudomonas aeruginosa*. The problem got better by using Aloe vera straight to the mouth ulcers. These lesions include, among others, canker sores, herpetic lesions, and aphthous ulcers. The decrease in bacterial, fungal, and

inflammation-related discomfort can benefit patients with loose dentures and painful ridges. The anti-inflammatory properties of this herb can be used to stop bacterial infections that could irritate dental implants (Seal *et al.*, 2016).

The herb *Ageratum conyzoides*, which can treat various ailments, is called the “king of plants” or “African panacea” in Cameroon. For tooth extractions and pain relief, the entire plant is used. This plant has anti-inflammatory, analgesic, and anti-diarrheal properties, as well as anti-cancer and antiradical properties that inhibit the growth of many microorganisms (Ashu and Naidoo, 2015).

To cure toothache and discomfort, Malay people prepare cooked coconut roots (akar pokok Kelapa) and use them as mouthwash. The decoction made from coconut trees is used as a mouthwash and gargle. Anti-bacterial, fungicidal, antiviral, and antioxidant properties of this plant have been demonstrated. The anticancer effect is caused by lauric acid from coconut flour, which is sensitive to *Streptococcus mutans* and reduces plaque bacteria and biofilm while also having an antifungal effect (Ashu and Naidoo, 2015).

The avocado pear plant, *Persea americana*, has anti-inflammatory and antifungal properties. Its boiled and crushed seeds are used to make a mouth rinse to treat toothaches and mouth ulcers (Ashu and Naidoo, 2015).

Use the sweet potatoes (*Ipomoea batatas*) leafy parts to treat toothaches. *Staphylococcus aureus*, *S. mitis*, *Candida albicans*, *Staphylococcus aureus*, and *Streptococcus mutans* growth is inhibited. According to Ashu and Naidoo (2015), it has anti-inflammatory, anti-mutagenic, anti-ulcer, and anti-diabetic properties.

The tropical forest tree *Garcinia mannii*, sometimes known as the “chewing stick,” has branches that can be used as a toothbrush or chewing stick. Regular use has been demonstrated to reduce dental pain and prevent cavities in teeth (Ashu and Naidoo, 2015).

In Malay, chamomile, also known as *matricaria recutita lavandula.*, is frequently sold as table tea (Daun teh). This chemical has sedative, analgesic, antispasmodic, antibacterial, and anti-inflammatory properties. Numerous active substances, including flavonoids, apigenin, luteolin, and quercetin, are present in chamomile flowers and are thought to be the basis for many of the herb’s therapeutic benefits. When used as a mouthwash, it is beneficial in defending gingival tissue and the oral cavity. It alleviates the symptoms of mucositis and slows or stops the growth of lesions (Seal *et al.*, 2016).

Garlic, or *Allium sativum* or Bawang Putih in Malay, is a popular culinary and medicinal herb. To relieve pain and avoid gingivitis, the paste made from the bulb is applied immediately to a toothache. It has a wide variety of antibacterial, antiviral, and antifungal properties. Garlic has a powerful antibacterial impact against dental plaque microorganisms even at very low doses (*Streptococcus mutans*, *S. sanguis*, and *S. salivarius*; *Pseudomonas aeruginosa* and *Lactobacillus spp*) (Ashu and Naidoo, 2015).

Flavonoids and polyphenols abound in cranberry or *Vaccinium macrocarpon* extracts. These are in charge of preventing tooth decay. It stops cariogenic bacteria from colonizing tooth structures and producing acid. They reduce inflammatory reactions. Furthermore, it prevents *Porphyromonas gingivalis* from adhering and the co-aggregation of periodontal diseases (Seal *et al.*, 2016).

Australian native *Melaleuca alternifolia* is also referred to as tea tree oil. Anti-fungal and anti-bacterial qualities. It can treat stings, burns, and irritation of the throat. People with chronic periodontitis can benefit from using tea tree oil gel for their periodontal treatment (Seal *et al.*, 2016).

Numerous products use propolis, including toothpaste, lozenges, and mouthwash. Additionally, it helps manage oral diseases, surgical wounds, endodontics, dental caries, and necessary pulp therapy. When used as an intracanal medicine to treat *Enterococcus faecalis*, propolis with Ca (OH)₂ shows antibacterial action, effectively eradicating the organisms. Although this medication has shown remarkable efficacy, it should be used cautiously as some people have experienced adverse side effects (Seal *et al.*, 2016).

Cinnamomum zeylanicum, known as “cinnamon” in Malay, is one of the plants used to treat several illnesses, including those that impair oral and overall health. Numerous studies suggest it has antibacterial and antifungal properties (Gupata *et al.*, 2015). Cinnamon has antibacterial activity against both Gram-positive and Gram-negative germs, according to Ooi *et al.* (2006). The main and active ingredient in cinnamon is cinnamaldehyde. According to a 2015 study by Gupata *et al.*, cinnamon and chlorhexidine mouthwash are equally effective at removing plaque from teeth.

Mentha spicata L, often known as mint or pudina in Malay, has been used worldwide as a toothpaste, breath freshener, and antimicrobial mouthwash (Kumar *et al.*, 2011) (Kee *et al.*, 2017).